



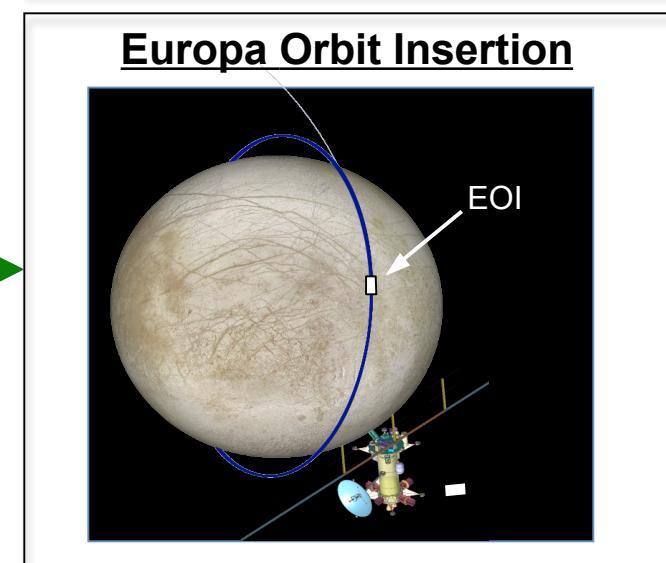
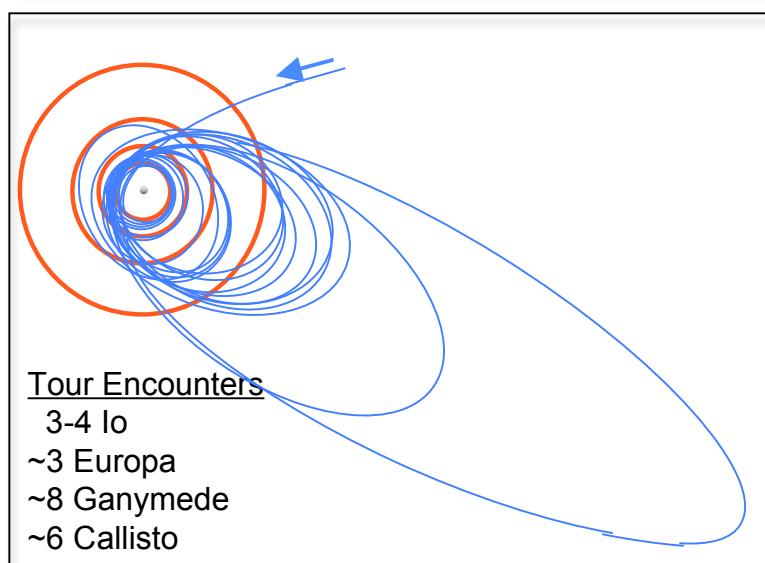
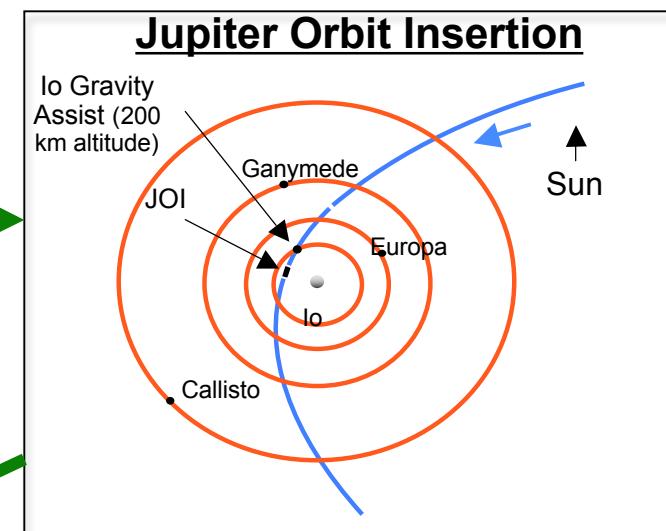
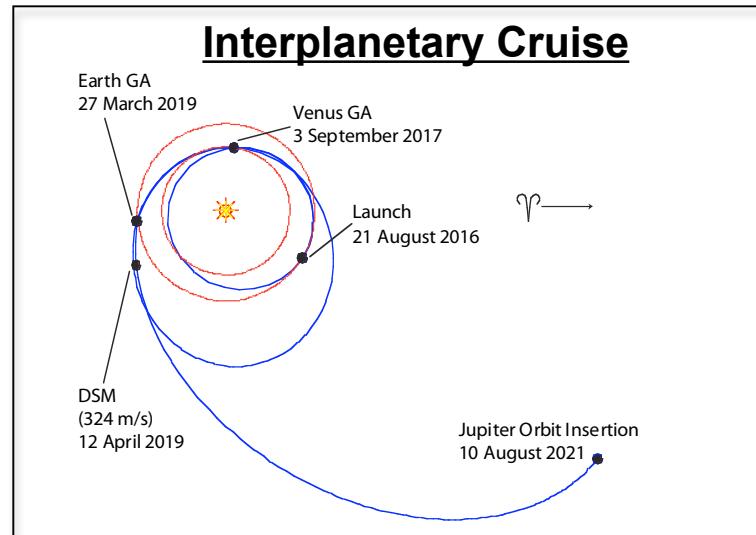
EJSM Europa Orbiter Science Scenarios

Rob Lock

Jet Propulsion Laboratory, California Institute of Technology



JEO Trajectory Delivers to Europa in 7 Years

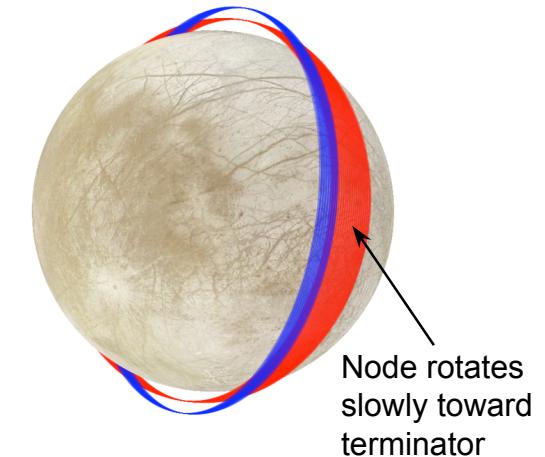
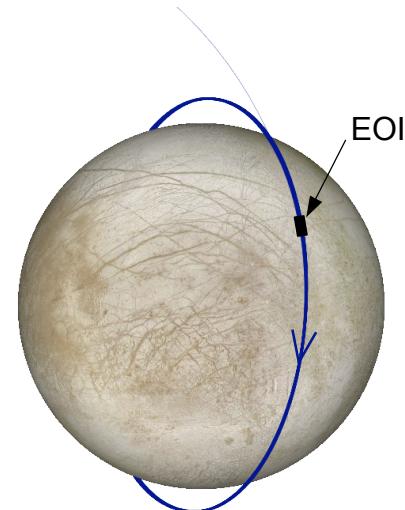




Europa Mapping Orbit

- Designed for early science in the first 28 days (8 eurosols) at 200 km altitude
 - Transition to a 100 km altitude after gravity field is well sampled
- Initial orbit node selected to provide ~2:30 pm LST
- Inclination selection
 - 91-92 deg inclination needed for sun synch
 - $85 \leq i \geq 95$ to meet Laser Altimeter constraints
 - Orbit rotates 0.1 to 0.4 deg/day
- Ground track repeat cycle selected for ground track separation and global imaging coverage
- Orbit Characteristics:

| Orbit Altitude (km) | Period (min) | Occultation Dur (min) | Orbits Per Day | Ground Speed (km/s) |
|---------------------|--------------|-----------------------|----------------|---------------------|
| 200 | 138 | 46 (33%) | 10.4 | 1.1 |
| 100 | 126 | 47 (37%) | 11.4 | 1.3 |

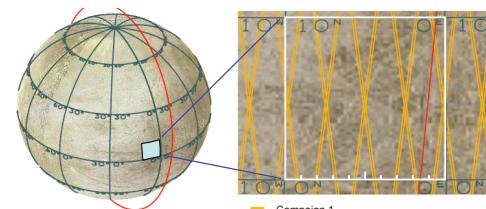
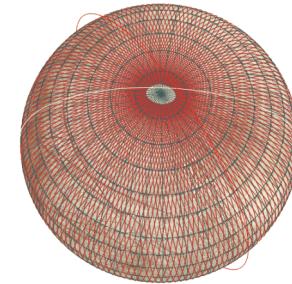




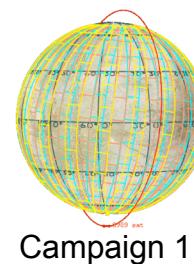
Data Acquisition Strategy - Orbit Design Issues

- Groundtrack repeat
 - 4 eurosol repeat in Campaign 1
 - 149 orbits
 - Global coverage in 3 eurosols
 - 8 eurosol repeat in Campaign 2
 - 327 orbits
 - Global coverage in 6 eurosols
 - Repeat cycle would be set for science needs, would be optimized when payloads are selected
 - Could be changed on orbit for small ΔV

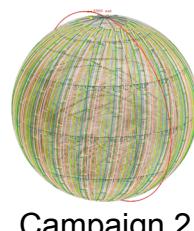
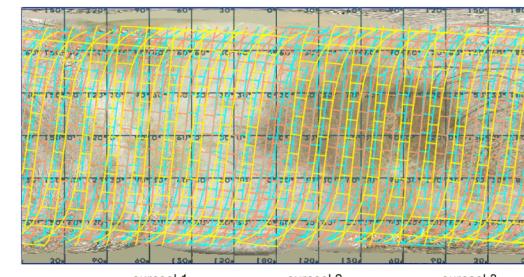
Groundtracks cover 95%
of Europa surface
Poles can be imaged
off-nadir (some layover)



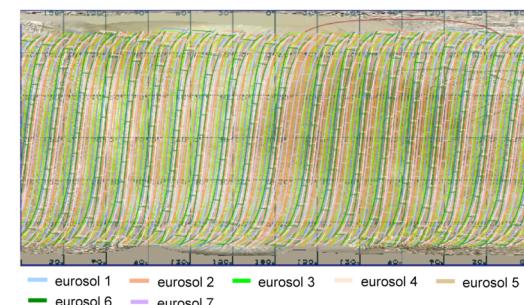
Nightside
Dayside



Campaign 1



Campaign 2





Scenario Development Process

- Scenarios Developed in SDT meetings
 - Science and engineering members worked concurrently
 - Tested observation and data return strategies, orbit designs, S/C modifications, campaigns during meetings or overnight if possible
 - Longer term analysis and simulation upgrades performed between meetings
 - Modified orbit design and spacecraft concept telecom and power based on operations scenarios trades
- Scenarios Optimized for Mission Objectives
 - Planning payload instrument parameters, S/C concept, mapping orbit design and high level constraints (data mgmt, telecom, DSN)
 - Developed initial mapping phase timelines, campaign strategies and observing strategies
 - Orbit simulations over 2 orbits provided feasibility and constraints for observing strategies



Data Acquisition Strategy - Analysis

SDT

Instrument data rates
Reduction factors
Coverage needs
Duty cycles

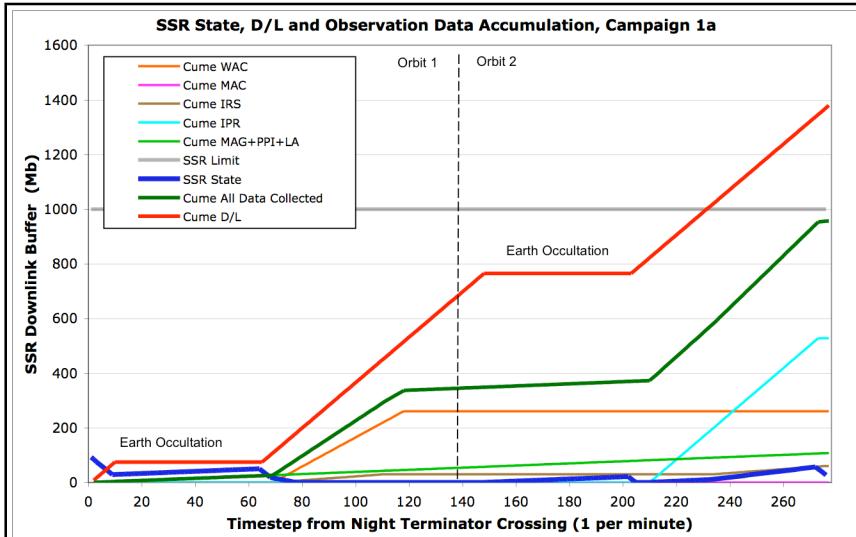
| Inputs | WAC | MAC | IRS | IPR | LA | PPI | MAG |
|--------------------------|--------|-------|-------|--------|--------|--------|--------|
| Raw data rate (Mb/s) | 0.36 | 1.78 | 0.03 | 30 | 0.002 | 0.002 | 0.0025 |
| Mapping orbit duty cycle | 35% | 0% | 30% | 45% | 100% | 100% | 100% |
| Data reduction rate | 4 | 4 | 2.5 | 215 | 1 | 1 | 1 |
| Uncompressed Dvol (Mb) | 1044 | 0 | 75 | 111780 | 17 | 17 | 21 |
| Compressed Rate (Mb/s) | 0.089 | 0.44 | 0.012 | 0.140 | 0.0020 | 0.0020 | 0.0025 |
| Total Dvol/Orbit #1 (Mb) | (0.14) | 260.9 | 0.0 | 30.2 | 0.0 | 16.6 | 16.6 |
| Total Dvol/Orbit #2 (Mb) | (0.14) | 0.0 | 0.0 | 30.2 | 527.4 | 16.6 | 16.6 |
| Total Dvol/2Orbit (Mb) | | 260.9 | 0.0 | 60.5 | 527.4 | 33.1 | 41.4 |

Constraints

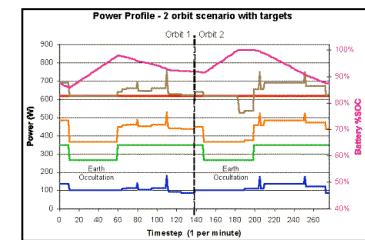
S/C:
3m HGA
13 W TWTA
1 Gb SSR

DSN:
34m Ka-band, 3/day

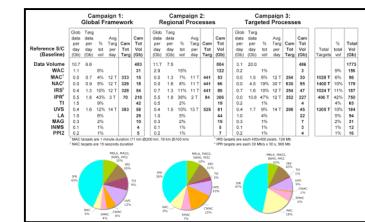
Operations:
No retransmit
Most observations during D/L



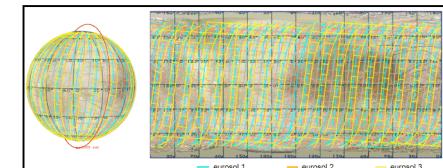
Power Profile



Data Return



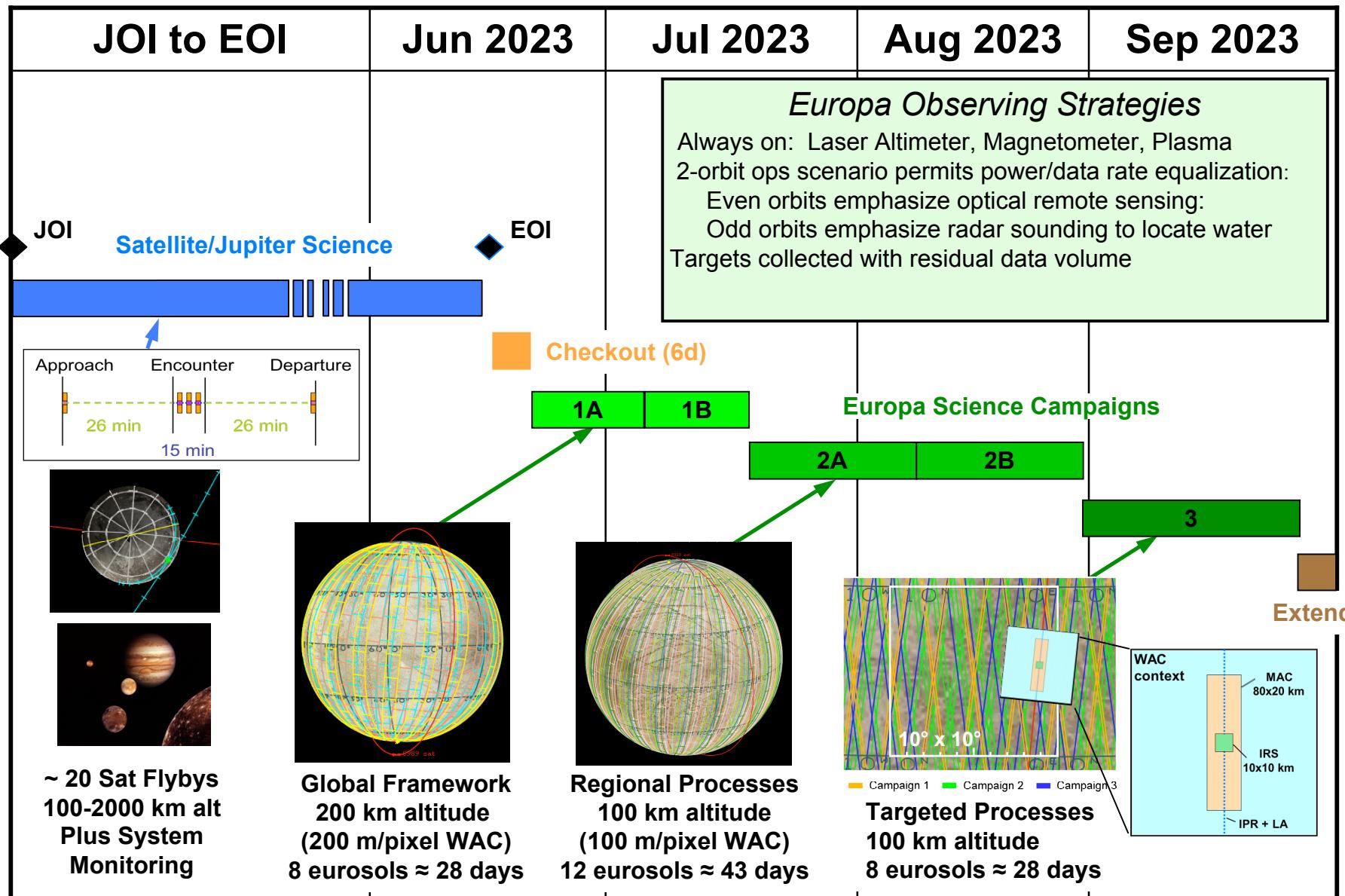
Coverage Estimates



- Data flow simulator used to model observation strategies over 2 orbits
- Each campaign is evaluated with new rates and observation parameters
- Power profiles calculated from worst case observation scenarios



JEO Science Scenarios





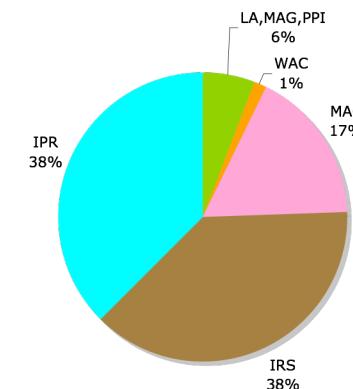
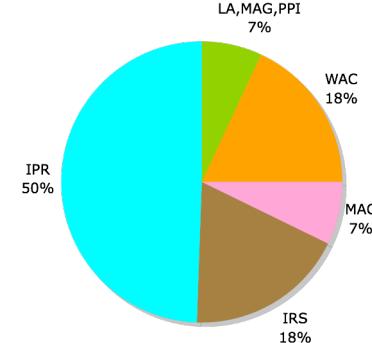
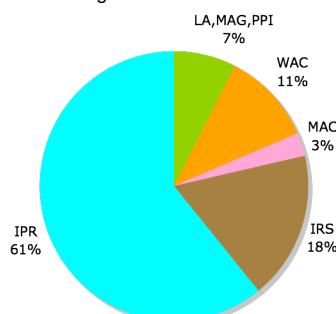
Europa Science Phase Performance

| Reference S/C (Floor) | Campaign 1 | | | | | Campaign 2 | | | | | Campaign 3 | | | | | All Campaigns | | | | | |
|--------------------------|------------------------------------|------------------------------------|-----------------|--------------------|--------------------|---------------------------|------------------------------------|------------------------------------|-----------------|--------------------|--------------------|---------------------------|------------------------------------|------------------------------------|-----------------|--------------------|--------------------|---------------------------|------------------|-------------------|----------------------|
| | Glob data per day (Gb) | Targ data per day (Gb) | % tot vol | Targ per day | Cam Tot Targ | Cam Tot Vol (Gb) | Glob data per day (Gb) | Targ data per day (Gb) | % tot vol | Targ per day | Cam Tot Targ | Cam Tot Vol (Gb) | Glob data per day (Gb) | Targ data per day (Gb) | % tot vol | Targ per day | Cam Tot Targ | Cam Tot Vol (Gb) | Total Targets | % total vol | Total Vol (Gb) |
| Data Volume | 4.5 | 3.0 | | | | 213 | 10.0 | 5.9 | | | | 339 | 1.4 | 8.2 | | | | 272 | | | 824 |
| WAC | 0.8 | | 11% | | | 23 | 2.8 | | 18% | | | 61 | 0.1 | | 1% | | | 4 | | | 88 |
| MAC¹ | 0.0 | 0.2 | 3% | 8 T | 230 T | 6 | 0.0 | 1.1 | 7% | 16 T | 341 T | 24 | 0.0 | 1.6 | 17% | 23 T | 653 T | 46 | 1224 T | 9% | 77 |
| IRS² | 0.3 | 1.0 | 18% | 8 T | 227 T | 38 | 0.9 | 2.0 | 18% | 16 T | 341 T | 62 | 0.7 | 2.9 | 38% | 23 T | 653 T | 104 | 1222 T | 25% | 204 |
| IPR³ | 2.8 | 1.8 | 61% | 2 T | 57 T | 129 | 5.2 | 2.7 | 50% | 3 T | 64 T | 168 | 0.0 | 3.6 | 38% | 4 T | 114 T | 102 | 234 T | 48% | 399 |
| LA | 0.2 | | 2% | | | 5 | 0.3 | | 2% | | | 7 | 0.2 | | 2% | | | 5 | | | 17 |
| PPI | 0.2 | | 2% | | | 5 | 0.3 | | 2% | | | 7 | 0.2 | | 2% | | | 5 | | | 17 |
| MAG | 0.2 | | 3% | | | 6 | 0.4 | | 3% | | | 9 | 0.2 | | 2% | | | 6 | | | 21 |

¹ MAC targets are 1 minute duration (71 km/min @200 km, 78 km/min @100 km)

² IRS targets are each 400x400 pixels, 128 Mb

³ IPR targets are each 30 Mb/s x 30 s, 900 Mb





Jupiter System Scenarios

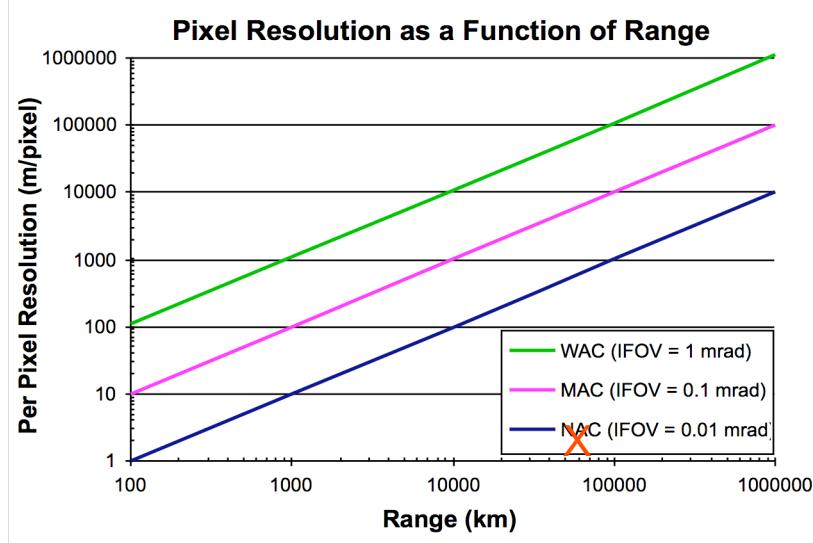
Tour Science Feasibility Study

- Quick analysis of tour encounter opportunities
 - Trajectory not designed for science
- Data collection similar to Europa Mapping
 - Instruments designed for mapping orbit
 - Data rate and volume constraints limit amount collected per encounter
 - Alternating encounter collection for imaging vs IPR

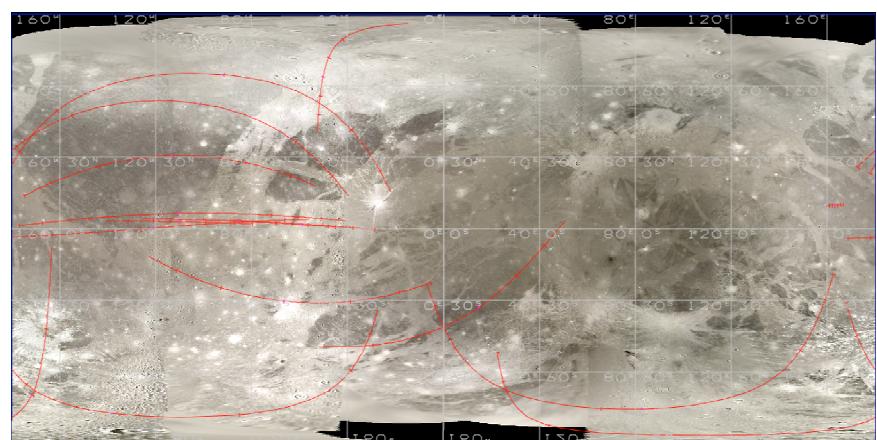
System Tour Encounters

| | Opportunities | Ranges (km) | Phase Angles (deg) | Ground Speeds (km/s) |
|----------------------|---------------|---------------------|--------------------|----------------------|
| Jupiter | 40 | 560,000 - 1,000,000 | 10 – 100 | |
| Encounters | | | | |
| <i>Callisto</i> | 4 | 400 - 3100 | 80 – 120 | 2.8 – 4.7 |
| <i>Europa</i> | 4 | 1400 - 800 | 60 – 100 | 0.4 – 1.9 |
| <i>Ganymede</i> | 14 | 100 - 2700 | 70 – 170 | 1.2 – 6.9 |
| Non-Targetted | | | | |
| <i>Callisto</i> | 1 | 325,000 | 70 | |
| <i>Europa</i> | 13 | 107,000 – 460,000 | 5 – 135 | |
| <i>Ganymede</i> | 7 | 28,000 – 430,000 | 55 – 114 | |
| <i>Io</i> | 17 | 276,000 – 490,000 | 8 – 174 | |

Encounter Resolution



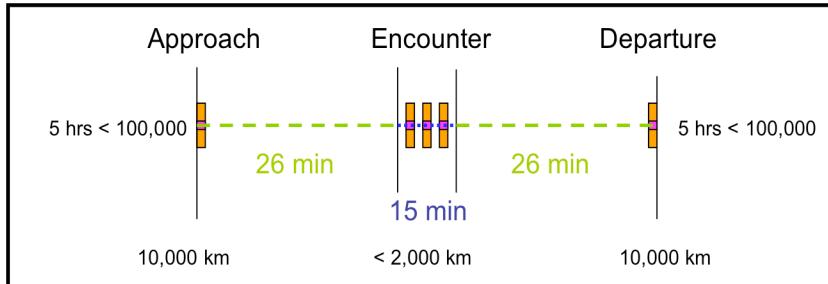
Ganymede Encounter Groundtracks



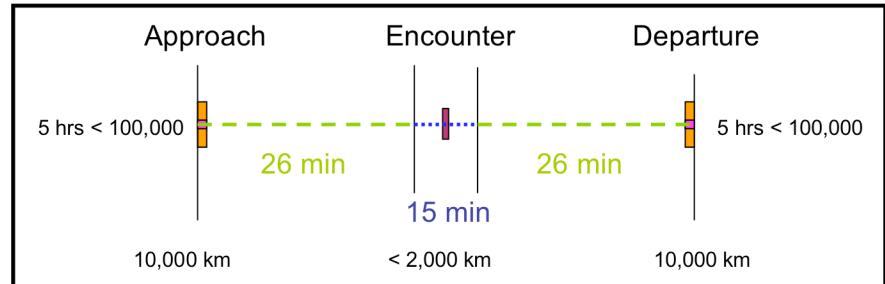


Encounter Scenarios

Close Encounter Imaging



Close Encounter Radar



- 1 Gb science data allocation
 - SSR limits data collection
 - Concurrent downlink for Doppler
 - Real time data return increases encounter data to 1.8 Gb
- Observations at closest approach
 - 3 coordinated images OR,
 - 1 IPR 30 second full resolution data take (with MAC and LA)
- Alternating Imaging with IPR observing encounters



DSN Strategy

- Ka-band 13 W TWTA, 3m HGA, 34m
- Dynamic Rate Selection takes advantage of DSN elevation and Jupiter Hot Body Noise
- Continuous 34m scheduled for first 3 campaigns (99 days)

